Rehabilitation, Revegetation, Reclamation and Restoration Research

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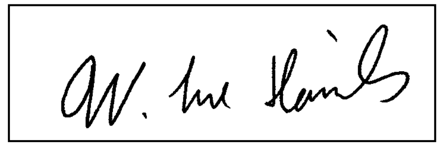
Memorandum



To: Mike Rolband, WSSI

From: W. Lee Daniels

Re: Progress Report for "Wetland Hydrology Studies"

Date: January 3, 2011

CC: John Galbraith, Virginia Tech
Gaber Hassan, Virginia Tech (former Research Associate)
Naraine Persaud, Virginia Tech
Nicole Troyer, Virginia Tech

This memo constitutes our progress report for the period between July 1 and December 31, 2010, for the WSSI administered project entitled "*Wetland Hydrology Studies*" which is also supported financially by the Peterson Family Foundation. As requested in our last progress report (July, 2010) the termination date for this project was extended to December 15, 2010, to allow for completion of one full year of field water level data collection at the Cedar Run 3 site. As discussed below, we completed that effort in mid-November and we are currently subjecting the data sets to detailed statistical and graphical analyses. Over the next two months we will compile a final research report from all phases of the project including the greenhouse mesocosm/sensor trials. We then intend to provide WSSI with a draft final report for review by March 15, 2011.

The overall goal of this research project is to critically evaluate and improve upon technologies currently available for accurately determining soil moisture/potential changes, water table level fluctuations, and the depth to saturation in fine-textured wetland soils. The overall methods employed and our results to date have been documented in earlier progress reports and will not be repeated here for the sake of brevity. Between October of 2009 and November of 2010, we monitored over 140 wells, piezometers and tensiometers of varying specifications and design at Cedar Run 3. With WSSI's assistance, the site was visited every two weeks for data recording and site observations. The installed monitoring array allowed us to compare a number of different monitoring well designs against the standard USCOE installation (open screened well to 18") and to further verify actual on-site soil saturation and hydraulic head conditions via comparison with adjacent nests of piezometers and/or tensiometers at varying depths. Currently, we (Nicole Troyer) continue to visit the site monthly to download data from the central electronic well arrays (as discussed below) for use in calibrating our parallel efforts on improved water budgeting procedures.

A map of the monitoring array installed at Cedar Run 3 for Plot 1 is attached as Figure 1 and a complete listing of the various wells/sensor installed at each of the three replications (Plots 1, 2 and 3) is also attached as Table 1. Following is a brief and preliminary description of the nature of the data sets and our current approach to analyzing this very large and complex data set. We are using the data gathered from Plot 1 as an example here, but it is important to point out that certain parameters and treatment relationships varied strongly among the three plots/replicates.

As described in earlier reports, each replicate plot contains a central set of piezometers, wells and tensiometers that are monitored electronically (Figure 1; Table 1) to generate a relatively continuous data set for one full year. The water level data for the three nested piezometers and the standard USCOE monitoring well for Plot 1 are given in Figure 2 along with the daily precipitation data. A preliminary analysis indicates that the standard USCOE monitoring well generated a similar water level response to both the shallow (6") and middle depth (18") piezometers, but did project an integrated water/head level between the two piezometers during the drier summer period. This would be expected since the open screened interval of the USCOE well intersects the open interval of both piezometers. Comparison of the shallow and middle piezometers indicates that the site may have been receiving subsurface discharge during the winter and spring (rising head with depth) but was losing water downward to recharge (falling head with depth) during the drier summer period. The interpretation of the deeper piezometer (installed into saprolite below the Btg) is not so readily understandable. While this zone was clearly hydrologically isolated from the surface, it did appear to "collect water" over the spring and summer of 2010. We believe that this may have been due to periodic drying and cracking of the high clay soil above it which may have allowed for some of the water perched above the expansive high clay Btg to slowly percolate downward. The rapid response of the shallow and middle piezometers and the USCOE well to rain events is also notable and was expected in this perching (epiaquic) soil hydrologic regime.

An important aspect of our monitoring design at Cedar Run 3 was to employ nested tensiometers at 6, 12 and 18 inches to determine when the soil transitioned between saturated vs. unsaturated conditions at those depths. The tensiometer data for Plot 1 are given in Figure 3 (attached). The data are presented here in negative kPa which are equivalent to centibars. At saturation, the tensiometers will be at/approach 0 kPa, and then as the soil dries out, the tensiometers will measure decreasing potentials down to approximately - 80 to 100 kPa (- 1.0 bar). As the soil dries beyond this point, the continuity of water films between the surrounding bulk soil and the porous cup on the tensiometer "breaks" and the readings again become 0 kPa and remain there until the soil wets sufficiently again to allow for readings within the functional range (0 to -80 kPa). Review of the tensiometer data (Figure 3) reveals that the deeper soils (18") appear to have remained saturated throughout the year. The fact that the shallow tensiometer recorded "apparently unsaturated" conditions during the winter period when the surface was clearly ponded/saturated (see Fig. 2) probably reflects an error due to freezing conditions. The 12" tensiometer does appear to respond relatively quickly to rain and wet/dry cycling events. Thus, we are hopeful that further detailed analyses of the 12" tensiometer data will allow us to isolate several time intervals for each site where we can accurately identify the day(s) where the saturated zone was either rising or falling through this depth. We will then compare this against the relative water level observed in all other wells/piezometers at each site to gain some inference into (A) which well designs were most accurate with respect to depth of the water table (e.g. the 0 potential surface) and (B) what the relative response time of the various wells or sensors was.

As shown in Figure 1, we also installed three replications of twelve different monitoring well or piezometer well designs around each of the central electronic monitoring arrays at each plot. The complete data set for all 36 wells for Plot 1 is shown in Figure 4 (attached) and the average value for each treatment (n=3) is shown in Figure 5 (attached). While all of the well designs generated a fairly similar overall seasonal response (hydroperiod) they do appear to vary as much as 10 to 15 cm in projected water levels during the wet ponded winter period and during summer wet/dry cycles (Figure 5). It is also apparent (data not shown) that the relative response of certain designs (e.g. open auger hole vs. ceramic cap piezometer) varied strongly among the three sites/plots. We are currently subjecting these data to a rigorous statistical analysis to determine (A) whether or not any significant differences in projected water levels occurred across all sites due to differences in well design (e.g. the 12 treatments), (B) whether or not any significant differences occurred within each site on certain key dates due to differences in well design, and finally (C), whether the three sites differed from one another in overall wetness/hydrologic regime.

As discussed in the opening section of this report, we are currently compiling and analyzing data from all components of this two year research project. This involves concurrent work by our Graduate Research Assistant (Nicole Troyer) who is completing her M.S. thesis focused on the Cedar Run 3 field data set and interpretations. We are also being assisted in the compilation of the earlier mesocosm/sensor study results by Dr. Gaber Hassan who has returned to his home university in Egypt.

We appreciate the continued support of WSSI and the Peterson Family Foundation in this work.

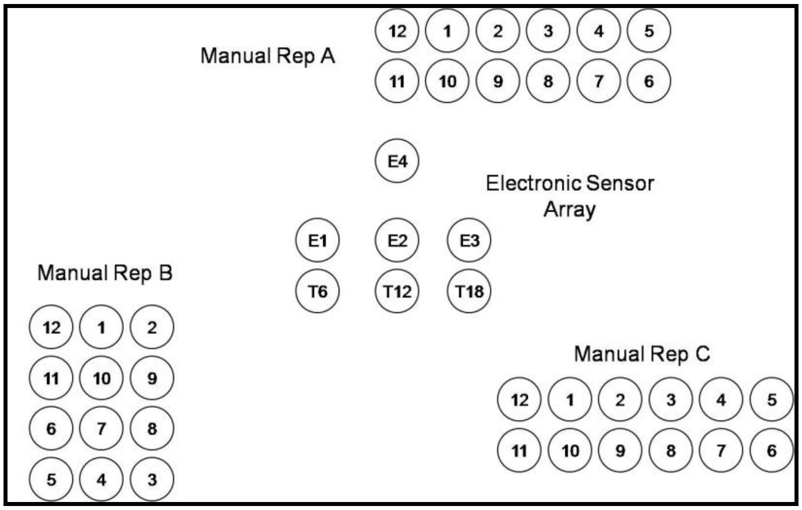


Figure 1. Layout of monitoring wells at Cedar Run Plot 1.

Table 1. Description of manually monitored wells/piezometers at each replicate.

Site	Type	Plot	Rep	Trt. code	Description
CR	E	P1	-	E1	Shallow piezometer, 1” above Btg, Global
CR	E	P1	-	E2	Middle piezometer, 18” below surface, RDS
CR	E	P1	-	E3	Deep piezometer, 1” below Btg, Onset
CR	E	P1	-	E4	USACOE Standard Well, 18” below surface, RDS
CR	E	P1	T6"	T6	Tensiometer @ 6”; silica flour pack
CR	E	P1	T12"	T12	Tensiometer @ 12”; silica flour pack
CR	E	P1	T18"	T18	Tensiometer @ 18”; silica flour pack
CR	M	P1	A	M1	0.75” open boring
CR	M	P1	A	M2	1.5” open boring
CR	M	P1	A	M3	0.75” well, sand pack, 2.75” boring
CR	M	P1	A	M4	1.5” well, SCL pack, 3.5” boring
CR	M	P1	A	M5	0.75” piezometer, sand pack, 2.75” boring
CR	M	P1	A	M6	1.5” piezometer, sand pack, 3.5” boring
CR	M	P1	A	M7	0.75” well, SCL pack, 2.75” boring
CR	M	P1	A	M8	1.5” well, sand pack, 3.5” boring
CR	M	P1	A	M9	0.75” well, no pack, tight fit
CR	M	P1	A	M10	1.5” well, no pack, tight fit
CR	M	P1	A	M11	0.5” ceramic piezometer, no pack, tight fit
CR	M	P1	A	M12	0.5” hand-cut piezometer, no pack, tight fit

Type: E = Electronic wells; M = Manual wells.

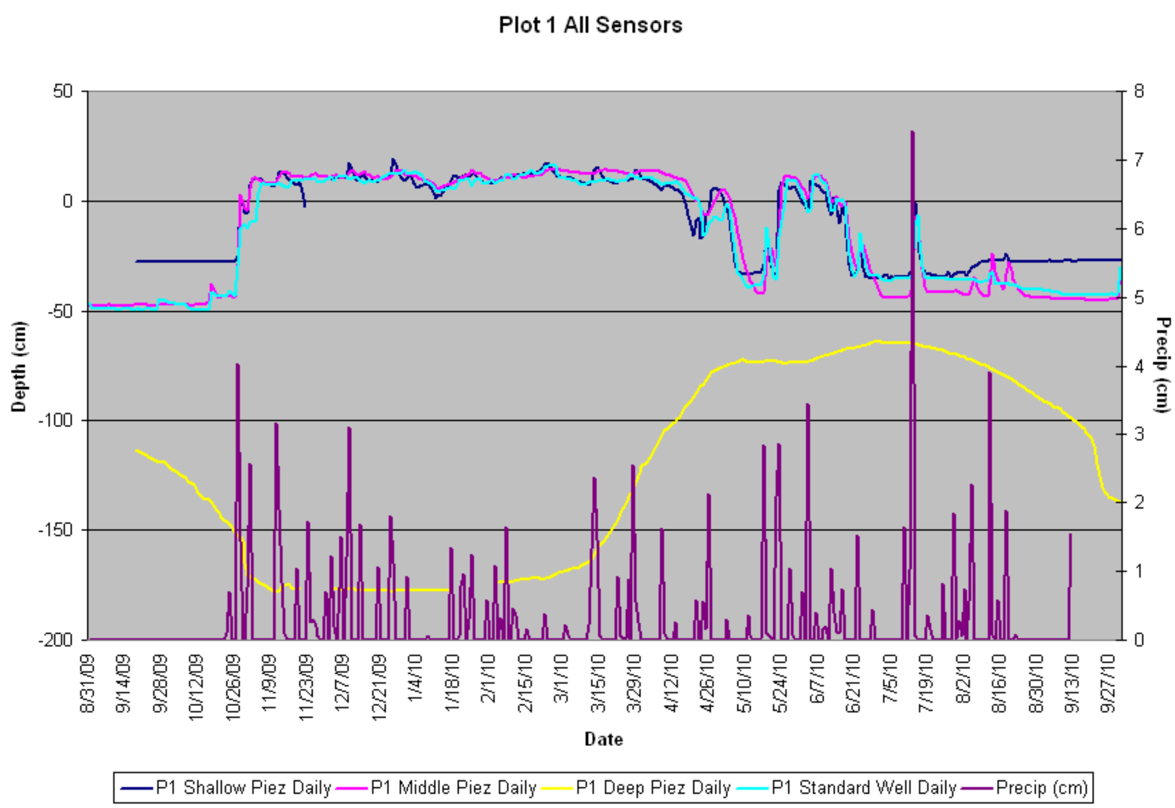


Figure 2: Piezometer nest, USCOE well (Standard Well), and rainfall data for Plot 1. See Table 1 for more information on treatment codes and depths.

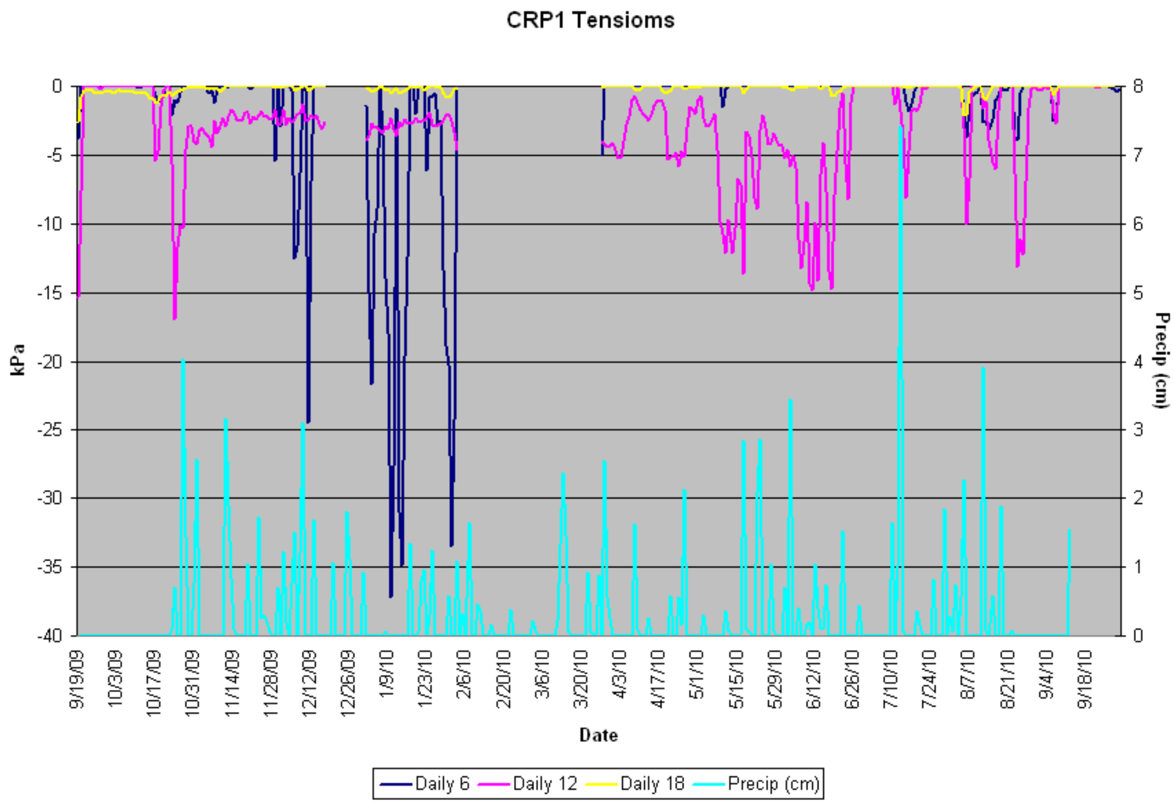


Figure 3: Tensiometer nest and rainfall data for Plot 1. See Table 1 for more information on treatment codes and depths.

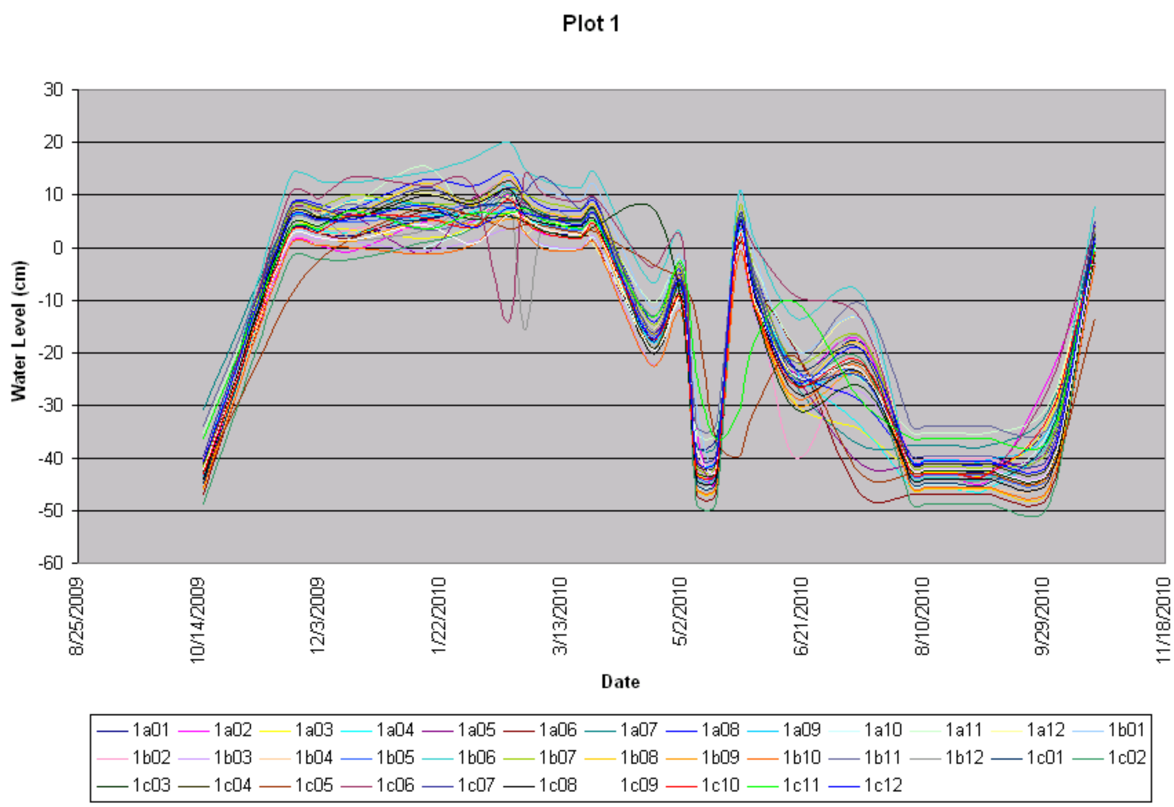


Figure 4: Water level data for all manual wells in Plot 1. See Table 1 for more information on treatments (e.g. 1a01 = Plot 1; rep a; Treat. M1). Note that the response curve here is “smoothed” by the plotting software.

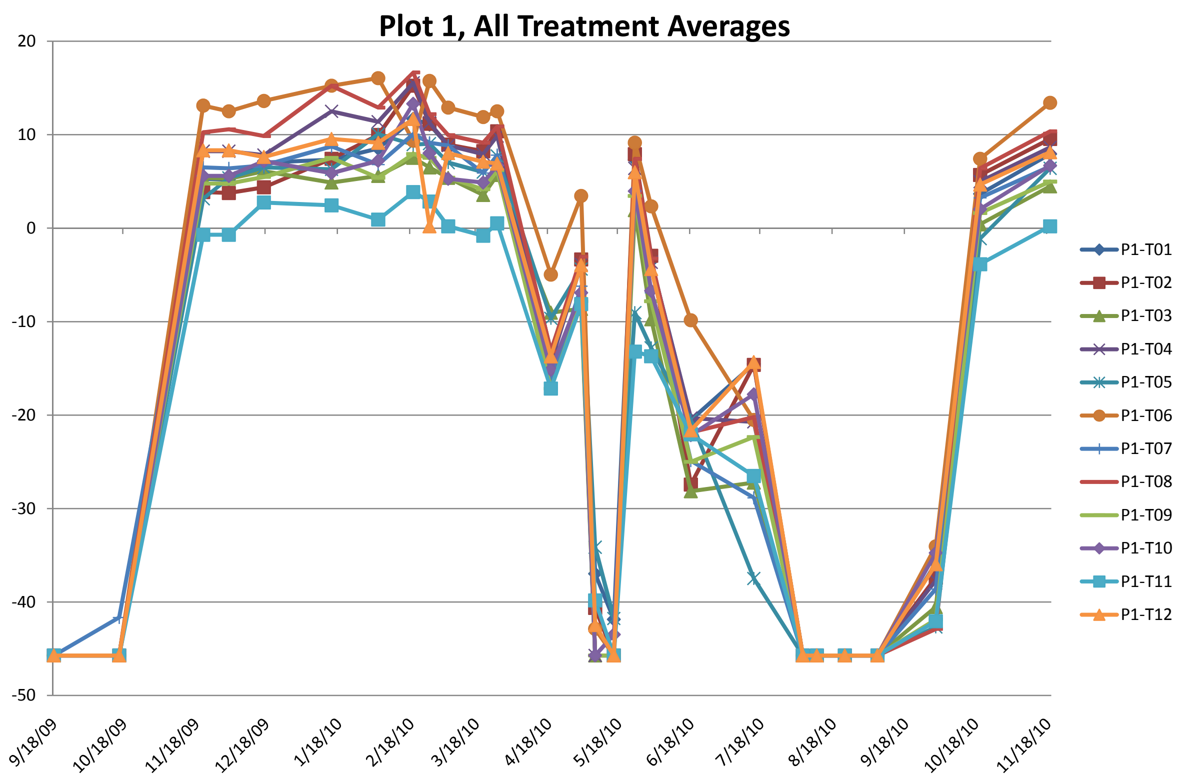


Figure 5: Average water data for all treatments in plot 1. See Table 1 for more information on treatments. Response curves are not “smoothed”.